Energy Efficiency

Introduction

The TEGCO Immingham Ltd Installation at Netherlands Way, Stallingborough, Grimsby, DN41 8DF is an Energy from Waste (EfW) process. The installation is designed to consume 320,000 Te/yr of Refuse Derived Fuel (RDF) based on 10 MJ/kg (LHV), producing: -

- 12 MW electrical export,
- 51 MW thermal export (60 Te/hr) as steam (no condensate return).

The installation is a Combined Heat & Power (CHP) plant sized and is designed to replace the steam and electricity currently generated by an existing CHP plant on an adjacent industrial plant. The existing CHP plant is reaching the end of its operational life and will be decommissioned when the installation is operational.

The need to continue to take waste in the event that steam and/or electricity cannot be exported (e.g. customer is shutdown), the installation is designed such that all steam generated at normal waste feed can pass through the turbine and condenser resulting in 24 MW electrical export.

A proportion of the RDF is sourced from local waste management companies and transported to the installation by road. The remaining is sourced from further afield and transported by rail to 1 of 2 local railheads and the final transfer from the railhead to the installation is by road.

The installation will operate continuously (24 hr/day & 7 day/week) for >8,000 hr/yr.

The installation consists of 2 off 20Te/hr incineration lines (combustor, boiler & feed-water system) and a single turbine and air cooled condenser.

The installation is designed not to generate any waste water from the process during normal operation.

The installation is designed to be fully compliant with the 2019 European BREF for Waste Incineration (JRC 118637) and the associated BAT Conclusions published in the Official Journal of the European Union on 3rd December 2019.

Basic Energy Requirements

In case of failure of the electricity supply, an emergency diesel generator will be provided to safely shut down the incinerator lines and to provide an emergency supply to the installation.

Appendix 1 contains Sankey diagrams for the following operating modes at the design point: -

- Sankey Diagram (CHP mode 60 tph export steam);
- Sankey Diagram (Full condensing mode no export steam).

The most significant electrical parasitic loads (under design conditions) include (but are not limited too) the following: -

- RDF handling systems (cranes etc.);
- Combustion Air Fans;
- Induced Draft Fans;

- Air cooled condenser;
- Boiler feed water system pumps;
- Air compressors;
- Flue gas cleaning reagents handling, storage and injection systems;
- Bottom ash, Fly ash and FGC residue handling and storage systems;
- Ancillary rooms.

The installation design includes all normal energy efficiency design features, such as high efficiency motors, high standards of cladding and insulation etc.

The incineration lines are designed to achieve high thermal efficiency, the design include: -

- The boilers are equipped with economisers and super-heaters to optimise thermal cycle efficiency without prejudicing boiler tube life, having regard for the nature of the waste that is being burnt;
- Unnecessary releases of steam and hot water will be avoided, to avoid the loss of boiler water treatment chemicals and the heat contained within the steam and water;
- Steam is used to the preheat combustion air;
- Steady operation will be maintained where necessary by using auxiliary fuel firing; and
- Boiler heat exchange surfaces are cleaned on a regular basis to ensure efficient heat recovery.

Delivered and Primary Energy Consumption

Energy is delivered to the installation in the following forms: -

- RDF
- Gas consumption (support & start-up based on 8,000 hrs/yr),
- Electricity import (based on 8,000 hrs/yr)

RDF

The installation is designed to burn 320,000 Te/yr of RDF at a lower heating value of @ 10 MJ/Te. This equates to a total input of 3,200,000 MJ/yr.

Gas

Natural gas is supplied from the National Grid and is used: -

- As support fuel as required by the directive,
- Start-up and shutdown fuel

Predicted gas consumption is 5,792 MWhr/yr.

Electricity

Electricity can be supplied from the National Grid and will be required: -

- During start-ups and shutdowns as internal generation is restricted/unavailable,
- To support critical loads when the installation is not operational.

Predicted electricity consumption is 44 MWhr/yr.

Energy Efficiency Benchmarks

Environment Agency Guidance Note – The Incineration of Waste (EPR5.01) indicates the benchmark for the generation of electricity from municipal waste incineration is 5-9 MW per 100,000 tonnes. When operating in electricity only mode the installation (at design point) will export 24 MW from 320,000 tonnes per annum of RDF. This equates to 7.19 MW per 100,000 tonnes of RDF. TEGCO therefore consider that the plant meets the EA benchmarks for recovery of electricity.

The EA document "210712 EA EfW EE BAT position V0.3" indicates that for new plants burning ≥200kt should achieve a minimum "Gross Electrical Efficiency" (calculated as defined in the BAT documents) of 30%. TEGCO therefore consider that the plant meets the EA benchmark for Gross Electrical Efficiency.

The 2019 European BREF for Waste Incineration (JRC 118637) BAT Conclusion 20 includes a BAT-AEEL of 25-35% Gross Electrical Efficiency for electricity only operation. Using the calculation (included in Appendix 3), the Gross Electrical Efficiency when operating in the electricity only mode is 30.49%. TEGCO therefore consider that the plant meets the BAT-AEEL benchmark for electrical efficiency.

The plant meets the definition of a "CHP plant oriented towards the generation of electricity" (as export steam can pass through the turbine in the event of no steam off-take) meaning that "Gross Electrical Efficiency" is the appropriate BAT-AEEL to use when assessing BAT.

The normal operating mode includes export of steam (i.e. CHP operation) to adjacent industrial user and the BAT-AEEL is 72-91% "Gross Energy Efficiency." Using the calculation (included in Appendix 2), the Gross Energy Efficiency when operating in the CHP mode is 75.94%. While not directly applicable (as the plant can operate in full condensing mode), TEGCO consider that the plant also meets the BAT-AEEL benchmark for Gross Energy Efficiency.

Operating and Maintenance (O&M) Procedures

The O&M procedures include the following aspects: -

- Good maintenance and housekeeping techniques and regimes across the whole plant;
- Plant Condition Monitoring is carried out on a regular basis to ensure: -
    - That motors are operating efficiently;
    - Insulation and cladding are not damaged;
    - That there are no significant leaks.
- Operators trained in energy awareness and encouraged to identify opportunities for energy efficiency improvements.

The control systems are designed to automatically adjust to variations in steam export when operating in CHP Mode.

Where practicable, maintenance is planned and undertaken in liaison with the steam customer.

The Plant is designed for continuous operation when the steam off-take is not available due to unplanned shutdown. In the event of loss of steam export, the excess steam will pass through the steam turbine generator giving additional electrical output.

The control systems for the boilers, steam turbine and steam export automatically adjust to a maintain the required steam and electricity output required.

Energy Efficiency Measures

An energy efficiency plan is built into the O&M procedures of the installation ensuring maximum, practical, sustainable, safe and controllable steam export and electricity generation. The plan is reviewed regularly as a requirement of the ISO 14001 management systems for the installation.

During normal operation, procedures are reviewed and amended, where necessary, to include improvements in efficiency as and when proven new equipment and operating techniques become available. The potential improvements are assessed using cost benefit assessment and implemented if appropriate.

Energy Efficiency Directive

Paragraph 1 of Schedule 8A of the EPR defines those activities which the fall under the scope of the Energy Efficiency Directive. This includes “a stationary technical unit where one or more activities listed in Part 2 of Schedule 1 are carried on”

The plant will be regulated as a Section 5.1 (b) activity, as stated in the application forms of the EP Application and therefore the requirements of the EED apply.

Paragraph 2 of Schedule 8A of the EP Regulations (inserted by the amending regulations at http://www.legislation.gov.uk/uksi/2015/918/regulation/6/made), states that “An application for the grant of an environmental permit under regulation 13(1) for a relevant installation which generates electricity must contain a cost-benefit analysis which assesses the cost and benefits of providing for the operation of the installation as a high-efficiency cogeneration installation”. This applies to the installation.

However, paragraph 1 of the Schedule 8A defines a cost-benefit analysis as “a cost-benefit analysis in accordance with Part 2 of Annex IX of the Energy Efficiency Directive”. Part 2 of Annex IX describes the requirements of a cost-benefit analysis, but begins with the paragraph “If an electricity-only installation or an installation without heat recovery is planned, a comparison shall be made between the planned installations or the planned refurbishment and an equivalent installation producing the same amount of electricity or process heat, but recovering the waste heat and supplying heat through high-efficiency cogeneration and/or district heating and cooling networks.”

The installation is designed and built to operate as a CHP plant with steam export to an industrial customer.

Therefore, as the plant is not an electricity-only installation or an installation without heat recovery, it is concluded that a cost-benefit analysis for opportunities for co-generation is not required.

Furthermore, the plant achieves the BAT AEELs for energy efficiency in both operational modes and is therefore considered to be designed to a high level of energy efficiency.

Further Energy Efficiency Requirements

The plant is not subject to a Climate Change Levy agreement.

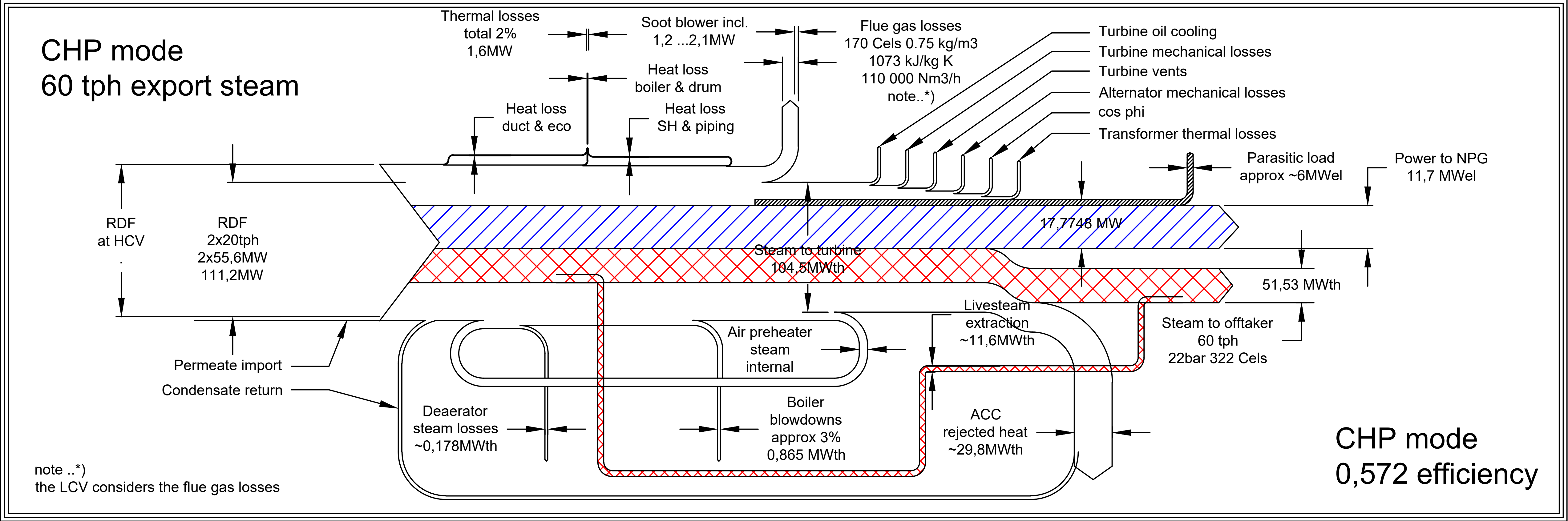
In accordance with the Waste Incineration requirements of the Industrial Emissions Directive, heat should be recovered as far as practicable. In order to demonstrate this, the following points should be noted:

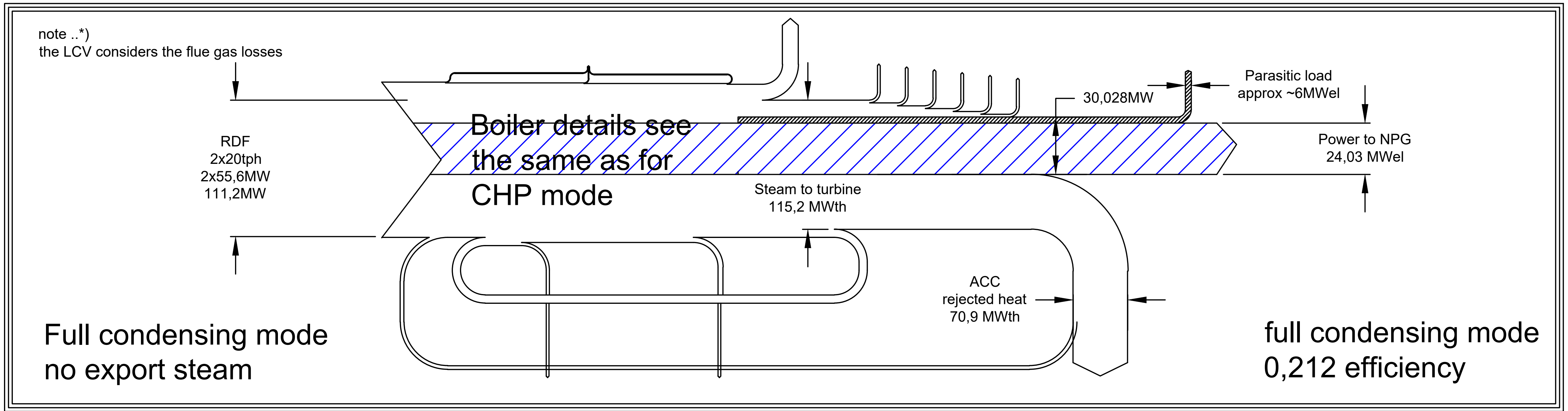
The plant will normally export 51.6 MWth as steam. The plant has been designed and normally operates in CHP mode, i.e. exporting both electricity and heat, to match the Off-takers electricity and steam demand. TEGCO therefore considers the plant to represent BAT for energy efficiency, and a CHP-R application is not required.

Non-Technical Summary

Appendix 1

1. Sankey Diagrams





TEGCO THE ENERGY GENERATION COMPANY GMBH COMBUSTION GASIFICATION

Refer to protection notice ISO 16016
Schutzvermerk ISO 16016 beachten !

TEGCO AutoCAD

					GEZ./DRAWN	20221220	Kraft	KUNDE/PURCH.		BENENNUNG/TITLE Sankey diagram Energy flow (CHP vs cond.) comparison
					GEPR./CHECK			ANLAGE/PLANT	EfW Immingham	
A	draft	20221220	AK	RC	AD	GES./APPR.	Engg.	ORDER- NR.	1900110	
A/M	REVISION/MODIFICATION	DATUM/DATE	NAME	GP/CH	GS/AP	MASSSTAB/SCALE	nts	MODEL	TEG1_PFA_TEB110009_A	

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KKS	DAS/DCC	Z. NR./DWG. NR	REV.	BL./SH.	VON/OF	
	1N & PFA	TEG1 TEB 110009	A	001/001		A3

Non-Technical Summary

Appendix 2

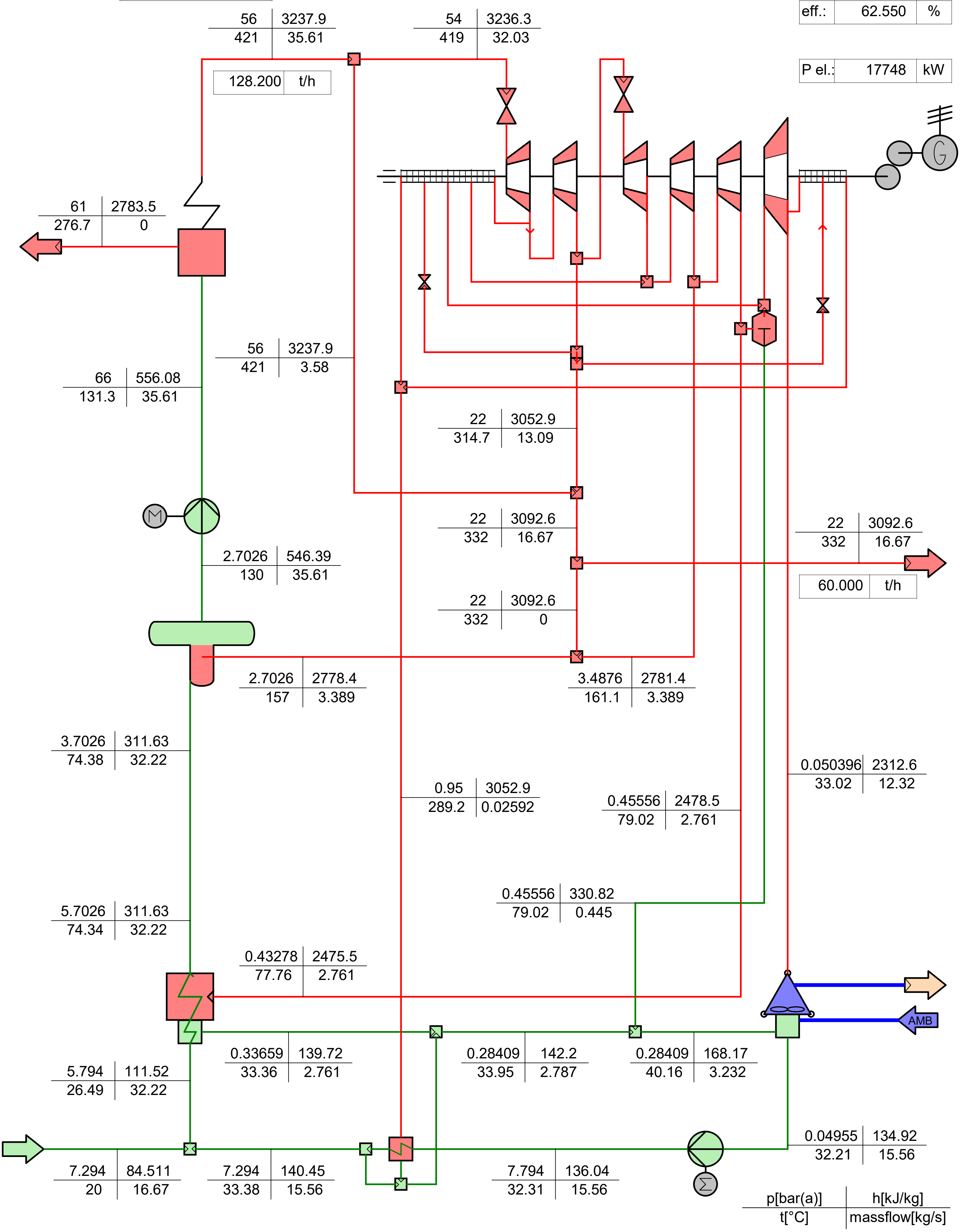
1. **HMB 60t Extraction Mode**
2. **HMB Condensing Mode**

PROJECT NAME : IMMINGHAM TEG1 **PROJECT-No.** :
ISSUE DATE : 21.12.2022 **REVISION** :

HEAT BALANCE DIAGRAM

PRELIMINARY - VAR 13

LOAD POINT: B



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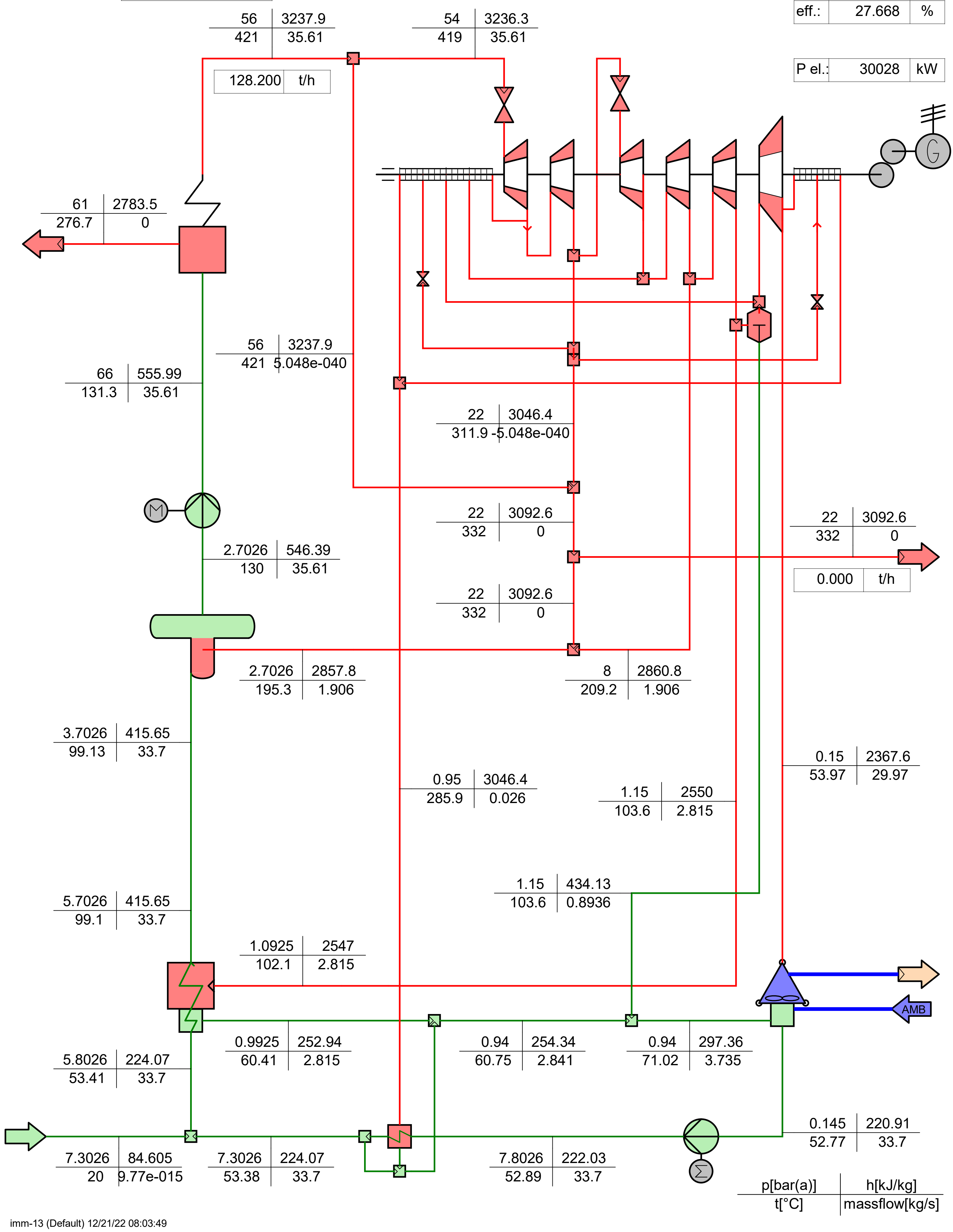
PROJECT NAME : IMMINGHAM TEG1
ISSUE DATE : 21.12.2022
PROJECT-No. :
REVISION :

HEAT BALANCE DIAGRAM

PRELIMINARY - VAR 13

LOAD POINT: A

eff.:	27.668	%
P el.:	30028	kW



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Non-Technical Summary

Appendix 3

1. **“Gross Electrical Efficiency” BAT calculation**
2. **“Gross Energy Efficiency” BAT calculation**

1. Gross Electrical Efficiency

Turbine Electrical Output	W_e	30.028 MW_e
Thermal Power Supplied	Q_{th}	111.1 $MW_{th\ (LHV)}$
Thermal Power Ex Boiler	Q_b	115.3 MW_{th}
Internal Thermal Power Use	Q_i	5.453 MW_{th} (De-aerator) 7.178 MW_{th} (Boiler Water Preheater) 0.388 MW_{th} (Turbine Blowndown Condensate) 0.079 MW_{th} (Turbine Gland Sealing Steam) 13.098 MW_{th} Total
Gross Electrical Efficiency		100x(30.028/111.1)x(115.3/(115.3-13.098)) 30.49%

2. "Gross Energy Efficiency" BAT calculation

Gross Energy Efficiency

Turbine Electrical Output	W_e	17.748 MW_e
Thermal Power Supplied	Q_{th}	111.1 $MW_{th\ (LHV)}$
Thermal Power to H/Ex	Q_{he}	0.000 MW_{th}
Thermal Power Exported	Q_{de}	51.55 MW_{th} (Steam Exported) 1.409 MW_{th} (Water supplied by off-taker) 50.14 MWth (Nett)
Internal Thermal Power Use	Q_i	9.416 MW_{th} (De-aerator) 6.835 MW_{th} (Boiler Water Preheater) 0.147 MW_{th} (Turbine Blowndown Condensate) 0.079 MW_{th} (Turbine Gland Sealing Steam) 16.477 MW_{th} Total
Gross Energy Efficiency		100x(17.748+0+50.14+16.477)/111.1)
		75.94%